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Transportation Research Procedia 14 (2016) 547 – 556

Transportation Research Procedia

www.elsevier.com/locate/procedia

6th Transport Research Arena April 18-21, 2016

# A methodological and practical approach to multidisciplinary assessment of the expansion of EU transport network: a strategic case for the republic of Croatia

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**Abstract**

The paper addresses application of Multi-Criteria Assessment (MCA) methodology to evaluation of transport development options to connect two separated parts of the Republic of Croatia. Selected theoretical and practical aspects of MCA are addressed and efficiency of MCA application to multidisciplinary transport projects is evaluated. Mutual relationships between CBA, traffic modelling, and MCA are discussed.


Peer-review under responsibility of Road and Bridge Research Institute (IBDiM)

*Keywords:* multiciteria assessment; Croatia; MCA

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Peer-review under responsibility of Road and Bridge Research Institute (IBDiM)
doi:10.1016/j.trpro.2016.05.110

## 1. Background

The land territory of Croatia is separated in two parts by the City of Neum located at the seashore of Adriatic and by a 14 km wide territory of the Bosnia and Herzegovina (B&H). This creates a very complicated and multidimensional challenge to providing continuity of the European Union land territory. The land discontinuity creates problems in communication, transportation, legal aspects which adversely affect regional economies, and complicate achieving long-term EU/Croatia objectives. The situation also touches EU's relationships with a non-EU country (Bosnia and Herzegovina). The provision of territory continuity is definitely consistent with the principles of the EU Cohesion Policy. Several initial transport connections and development options for providing connection were developed by the EU and the Croatian Ministry of Transport (hereinafter: Ministry) (Table 1)

This specific situation calls for consideration of multidisciplinary and multidimensional aspects of project prioritization. For that purpose the multi-criteria assessment approach (MCA) seemed to be the best and likely to provide the most educated and correct answers. Multi-criteria assessment is needed when there are no simple and one discipline type answers. In such circumstances a typical CBA may be misleading and result in false advice and choices. The best C/B ratio solution may be not most advantageous socially, geopolitically, and even economically. A methodology for assessment of the development options was defined together with the Ministry. For this paper, it was assumed that readers have basic comprehension of the MCA methodology. The paper hence concentrated on several selected and most challenging elements of this practical application, and resulting conclusions on enhancing the MCA methodology. This application approach was composed of four major analytical blocks: Cost Benefit Assessment, Multi-criteria Analysis (including all the input assessment), Multidimensional Evaluation, and Interpretation of the Results. A number of steps were undertaken: Final definition of transport infrastructure development options; Assessment of socioeconomic conditions and regional development; Evaluation of existing road infrastructure; Assessment of existing traffic conditions, including the O-D survey results and analysis; Evaluation of technical aspects of development options; Legal assessment. This approach combines standard and fully accepted methodologies of CBA with MCA which sometimes is criticized as a tool representing political interests. This combination may add to the value of the assessment. On the other hand, politics is frequently involved in EUs transport infrastructure decisions. This methodology was applied on practice for finding the best option for transport connection of two parts of Croatia in 2014 and represents mutual methodological agreements between experts, researchers, EC bureaucrats and politicians. The results of this application created a basis for making an investment decision – to build a bridge connecting two parts of Croatia.

Table 1. A List of development transport options for connecting two parts of Croatia.

| |
|---|
| **Option A:** Bridge: Mainland – Peljesac peninsula with access roads to the bridge, and:<br>**A1**: with a new road across the Peljesac peninsula to the state road D8<br>**A2**: without a new road across the Peljesac peninsula to the state road D8 |
| **Option B:** Neum bypass with connecting roads – city road corridor through B&H with special traffic regime (and status) in the Neum background (city in B&H) |
| **Option C**: Highway corridor through B&H with special traffic regime (and status) in the Neum background (city in B&H); |
| **Option D:** Long distance ferries with rehabilitation of existing peninsula road (Reconstruction of existing road and partial construction of new road across the Peljesac peninsula from the ferry port Trpanj to the state road D8, using existing ferry connections) |
| **Option E:** Short distance ferry line (on position of Pelješac bridge) with connecting roads and:<br>**E1**: with a new road across the Peljesac peninsula to the state road D8<br>**E2**: without a new road across the Peljesac peninsula to the state road D8 |
| **Option F**: Immersed tunnel to the Pelješac peninsula with access roads and:<br>**F1**: with a new road across the Peljesac peninsula to the state road D8<br>**F2**: without a new road across the Peljesac peninsula to the state road D8 |
| **Option G**: Tunnel under B&H |
| **Option H**: Adrian-Ionian Motorway (AIM) |

## 2. MCA for Croatia – initial assumptions

A catalogue of factors which had to be used within MCA for assessment of development options involved: Financial impact (value for-money for development options); Development option long-term sustainability, Impact on economy and environment in target area; Requirements of Schengen Acquis and in particular the Schengen border

Code (Regulation 2006/562), Customs control, veterinary and phytosanitary inspection; Trans-European Transport Networks; Likely political impact and the United Nations Convention on the Law of the Sea, Existing and future environmental legislation and in particular Natura 2000, the Maritime Directive and also proposed Natura 2000 sites in the targeted area, Opportunity costs of one option against others; Legal implications. The general MCA approach adopted for this assignment is shown graphically in Figure 1.

## 3. MCA methodology

**Basic definitions.** There are a number of basic terms that have to be used and understood uniformly throughout the MCA activities. Major definitions are: a) ***Criteria –*** sets of indicators that relate to separate and distinguishable components of the overall objective for the decision. Criteria are logically defined and interconnected and reflect the commonly accepted in literature and practice MCA standards; b) ***Indicators*** are the measures of performance by which the options are judged. They reflect important aspects of project objectives. Indicators may be either quantitative or qualitative. In the latter case, the methodology of the assessment is clearly provided to lowers risks which could be caused by indicators which are prone to strictly subjective opinions, c) ***Weights*** represent the value of impact of indicators on the assessment of the criteria, d) ***Preferences*** represent points of view of different stakeholders concerning the importance of the criteria in the project assessment.

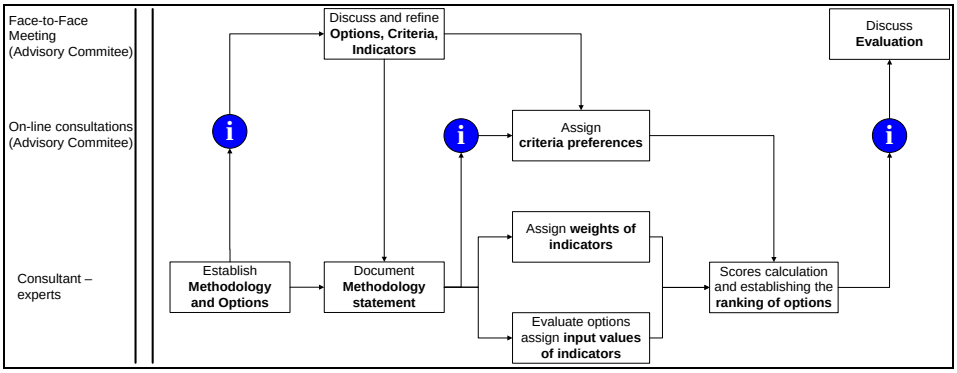


Fig. 1. MCA approach.

**Methodology for Project Scoring.** The MCA results in assigning final scores for each transport development option. This allows for prioritization and selection of the most preferable solution. The system of assigning final scores involves six steps addressed the following paragraphs.

**Step I: Assigning input values of indicators.** It involves assigning input values corresponding to the results of project options assessment for each indicator. The input values may be expressed in quantifiable or qualitative terms, based on a professional expertise of evaluators. The input values are summarized in an input table

**Step II: Normalization of indicator values.** In the input table, each indicator has values which may be expressed in various units and in different ranges (maximum and minimum). It is necessary to normalize these values to one comparable range and unit to allow for assigning a total score reflecting all indicators. In this MCA methodology, the normalization process is conducted, for each indicator, by mapping the indicator's values onto the [0,100] interval. It is done by the recalculation of the indicator's values into a scale between 0 and 100, considering its maximum – minimum range (extent). This involves assigning 100 to the highest score and 0 to the lowest score. Consequently every indicator *i* of the criterion *k* may be expressed, for a given project *p* with an normalized value $S_{ik,p}$ that is between 0 and 100: $0 < S_{i,k} < 100$.

**Step III: Assigning weights to indicators**. Once impacts (indicator values) have been normalized, the indicators are mathematically comparable. They are however, not necessarily equally important for the purposes of criteria assessment. Therefore, the set of indicator weights is defined. The weights reflect the level of importance of each indicator in the assessment process within criteria. Weights are developed based on the professional expertise and according to the objectives of MCA. The weights are expressed by weight factors which represent the impact of a given indicator on the final score calculation within the criterion.

**Step IV: Score calculation for each criterion per project**. Assigning the score for each criterion is conducted by summing up: a) indicator scores, b) multiplied by weights of these indicators. For each alternative *p*, the score of the criterion *k* is characterized by the scores for each indicator $S_{ik,p}$ and its weight $A_{i,k}$ given by the sum:

$$S_{k,p} = \sum_{i=1}^{n} S_{ik,p} A_{i,k} \tag{1}$$

**Step V: Assigning preferences of the criteria.** The stakeholders, may have special preferences as to the importance of factors used for final assessment of development option. If they do not, the MCA is usually completed on the assumption that all the factors are equally (proportionally) important. To identify the preferences, according to the standard MCA procedures, the stakeholders are asked to give their relative preferences for impact criteria. Preferences represent points of view of various stakeholders concerning the importance of the criteria in the assessment. Usually, it is done by the means of survey forms, but verbal expression is also acceptable. In this case, a set of joint preferences was developed based on input received from the project Advisory Committee input. According to the literature on group decision-making, the approach adopted is that of considering the collective result, obtained by the aggregation of individual preferences, and is the result of consensus. Jabeur & Martel (2007)

S**tep VI: Score calculation for project options.** The scores of the options represent the final result of MCA analysis. The score of the option *p* is the result of summing the products (values) between scores $S_{k,p}$ and preferences $A_k$ attributed to each criterion *k*:

$$S_p = \sum_{k=1}^{m} S_{k,p} A_k \tag{2}$$

The $S_p$ is the final score for option *p* that will be adopted in order to set-up a ranking among all development options.

## 4. MCA criteria and Indicators for application in Croatia.

In this assignment **five criteria were established** for evaluating development options: Economic sustainability; Regional development impact; Technical improvements and risks; Environmental sustainability; Geopolitical and legal impact. The evaluation criteria must provide for complex and comprehensive overview of the effectiveness, sustainability and feasibility of development options. They should result in a fair and justified multidisciplinary assessment of these options. This assessment was designed to create a sound and defendable basis for identifying the most desirable developed option. A very important issue is to eliminate duplicity in criteria definition. According to the standard MCA methodology the same factor cannot be used twice to assess projects or options. This is a commonly committed mistake in MCA. It is therefore, very important that a thorough review of criteria be conducted prior to the assignment of evaluation criteria. The final evaluation of investment projects should be based on: a) assessment of project subjected to the scoring system (direct evaluation) and b) assessment of other factors which add or supplement the scoring categories (indirect evaluation). The next important principle is to achieve full understanding and consent of all stakeholders regarding the accepted set of evaluation criteria. Once they are agreed upon they should not be changed in the course of evaluation process. This is based on practical experiences described in the MCA literature. There are many instances indicating that very often some stakeholders faced with unfavourable assessment results attempt to change the criteria to enforce preferred evaluation outcomes. In MCA, where many evaluation process elements are qualitative, this should be avoided at any price, unless serious logical or methodological errors are proven. Some MCA experts call for maximization of quantitative criteria and indicators. This does not seem to be absolutely necessary. The MCA approach by its definition involves qualitative judgments and it should stay this way. More important is to insure full independence and professionalism by the evaluators, and eliminate any kind of pressure on them. They are supposed to provide logical reasoning and explanation of the evaluation activities. If some of evaluation requirements cannot be considered inside of the evaluation process due to any of the above reasons, according to the international standards they can and should be addressed separately to strengthen and explain the conclusions resulting from scoring.

## 5. Criteria description

A description and reasoning for criteria selected for evaluation of development options in this assignment has been provided below. **Economic sustainability.** Economic effectiveness is one of the most crucial factors in transport infrastructure projects evaluation, especially when the external funds are required to finance project implementation costs. It is even more important when the projects are going to be co-financed from public (tax-payers) funds such as the EU funds. The EU regulations clearly state that *one of the main criteria applied to ensure the high quality of the projects are their medium-term economic and social benefits, which shall be commensurate with the resources deployed; an assessment shall be made in the light of a cost-benefit analysis*. Council (1994) Therefore, the economic sustainability criterion used for this MCA concentrated on economic effectiveness of development options and took into consideration a balance between project costs and direct economic benefits resulting from the infrastructure improvements. **Regional development impact**. The impact of considered development options on regional development issues may be considered in two ways. First, it is very important to insure that there is a land connection between all EU/Croatia regions. The only way to address this problem is to find a permanent solution that will ensure unconstrained flow of goods and persons through the EU/Croatia and Schengen area, avoid any traffic bottlenecks negatively impacting development options from EU, the Balkan region, and Croatia perspective, ensure the security of the Schengen borders, provide for full consideration and implementation of EU regulations on the customs and transit of goods for all EU members. Also, lack of land territorial cohesion of EU in that region makes it very difficult to efficiently implement EU Cohesion Policy principles. In that perspective, the land connection is a major European Union problem that needs to be urgently and permanently addressed. Regional development and cohesion of Croatian territory are major priorities of „*Strategy of Regional Development of the Republic of Croatia*" dated June 1997. In Chapter 2.1 of this Strategy, it is stressed out that „the overall Croatian national territory should be completely and firmly integrated and all of its constituent parts should be quality and efficiently interconnected." Furthermore, Article 2.3. indicates that measures should be taken to „decrease the differences in development of individual areas, stop negative demographic trends, utilize insufficiently valorized potentials of certain areas and resources." The assessment of regional development impact is one of the major elements of transport infrastructure projects. Transport infrastructure does not only provide for better mobility of EU citizens and their trade, but also is a major catalyst of the overall economic and quality of life growth, which are major objectives of almost all activities of the Union and the key to competitiveness of the entire European continent in the global economy environment. The importance of these priorities were strengthened after Croatia accessed the European Union. The EU regulations indicate that investment projects should be evaluated according to *the priorities established by the beneficiary Member States*. Therefore, in the MCA methodology adopted, a regional development criterion defined as the impact of project options on regional socio-economic development and regional cohesion in short-term and long-term perspective. **Technical improvements and risks.** Each development option provides different technical results and contributions to transport system capacity. They also have different constraints and risks stemming from the adopted design and technology, and from the maturity of project preparation process. These issues have a significant impact on the efficiency and effectiveness of meeting objectives of development options, materializing the planned results. The MCA technical criterion reflects the abovementioned key aspects and risks of the project preparation, implementation and operation phases and advancements. **Environmental sustainability.** The contribution which projects make to the EU environment policies is a key issue impacting development option choice and its later implementation. This has been included in the adopted MCA scheme. The environmental impact of development options must consider crucial EU environmental policy priorities, for example investment impact on protected areas NATURA 2000, natural and man-made environment. **Geopolitical and legal implications.** The current separation the EU/Croatia territory Bosnia and Herzegovina (B&H) results in many legal issues which have a direct impact on the feasibility and sustainability of development options. Major areas of concern are related to the compliance with the UN Convention on the Law of the Sea, necessity for international agreement related to possible creation of road corridor or by pas through B&H territory (third country). Additional issues related to the Schengen Acquis and EU legal framework surfaced after Croatia joined the Union. As a result there is a complex and complicated legal situation which needs to be considered when assessing development options. It is necessary to measure how each option may contribute the improvement of this situation. There is also a large political and social area which has to be addressed. The land discontinuity of EU territory in the Neum area may contribute to social and political tensions. For example, a vast majority of the City of Neum residents are of Croatian decent. They and their children need unlimited and unconstrained access to the EU/Croatia territory for family reasons, school attendance, and other social needs. The construction of extraterritorial corridors in B&H territory may create unneeded regional tension in particular with predominantly Croatian population. This was confirmed during the origin-destination surveys and meetings with local governments in the target area. If

B&H joins the European Union, all these issues may be will be resolved partially without the need to construct temporary solutions like sealed corridors. The saved funds may be used to provide for transport solutions contributing to the increased quality of life of the current and future residents of the European Union. For example, about 60 to 70 percent of houses and dwellings in the Orebic area (Peljesac peninsula) are owned by the current citizens of B&H. The provision of a better access to this area which at the same time would insure the EU territory land connection would achieve additional political and economic benefits, and contribute to the improvement of geopolitical situation and creation of sustainable stability in the Neum region.

## 6. Definition of indicators

The five criteria defined in the previous paragraphs are general and need to be focused on particular representative indicators capable to reflect the effects and differences between the analyzed investment options. Indicators should be mutually independent of each other. No duplicate indicators are allowed. The evaluation of one indicator cannot influence the assessment of another, as much as possible, to avoid overlapping. In this way, the distribution of scores in the MCA will be as balanced as possible. It is therefore important to define exactly the content of each indicator, especially for those indicators that can be estimated only by qualitative assessment. The following indicators were defined: *Economic sustainability indicators*: EIRR; *Regional development impact indicators:* Social accessibility; Regional economic development, Compliance with regional development strategies; *Technical improvements and risks indicators*: Transport system capacity; Investment preparation risk, Engineering and geotechnical risk; *Environmental sustainability indicators*: Impacts on natural ecosystems; Impacts on protected areas; Impacts on man-made environment; *Geopolitical and legal impact indicators*: Compliance with the Schengen Acquis; International accessibility impact, Necessity of additional international agreements; Compliance with the UN Convention on the Law of the Sea. Some of the above indicators cannot be expressed in quantifiable terms. Therefore, qualitative assessment, based on a professional expertise, were used to express the impact of these indicators.

## 7. Weights

According to the MCA scheme, after criteria and indicators are established, weights and preferences are applied. Weights were applied by to indicators within each criterion. These are technical issues and decisions related to the concept and logic of the MCA activities. It is the external evaluator's prerogative to establish the strength of each indicator, and its impact on the final criterion evaluation. The weights are applied by the consultant/evaluator as a part of a technical design of MCA efforts. The situation is different for preferences which are usually assigned by the beneficiary or its agents. The preferences are applied to criteria, and reflect the Ministry's priorities for a given investment. According to the principles of the state-of-the-art MCA methodology, the indicator weighting system must adhere to several basic rules: Weights are attributed to indicators in percent; The total weight value within a criterion amounts to 100%; If more than two indicators are in a given criterion, the maximum weight for an individual indicator is fixed, and cannot exceed 50%; A minimum weight attributed to any indicator is also fixed. It cannot be smaller than the amount resulting from the following formula: $Wmin = \Sigma Wi\ 100/2n$, where Wmin – minimal weight attributed to an indicator $\Sigma Wi = 100\%$ – sum of the weighting of the different indicators in a criterion, n – number of indicators in a criterion. At the validation principles stated above, the weighting system assures that each indicator is properly taken into consideration, and enables avoiding generation of too many indicators and introducing "fake indicators" which exist but do not have the real impact on MCA results. The abovementioned validation procedures were applied to the MCA conducted within this assignment. One indicator for a criterion is used only in one case, for an economic sustainability criterion. One should however notice that this indicator (EIRR – Economic Internal Rate of Return) encompasses and considers several key financial and economic factors such as: investment cost, maintenance and operating costs, and monetized benefits of time travel savings, etc. Therefore, in this case, the application of a single economic indicator, fully complies with the principles of the validation procedure addressed in the preceding paragraphs. The weights applied to each indicator for the purposes of this analysis are shown in Figure below.

## 8. Preferences

The final stage of the integrated MCA methodology used in this study is preference application. Preferences were developed and applied in consultations with the Ministry and Advisory Committee. The final voice for criteria and preferences approval, was that of the Ministry. The initial assessment was done based on preferences suggested by

the Advisory Committee which were fully accepted by the Ministry. The Consultant also accepted these preference distribution. Subsequently, a number of sensitivity tests for other preference distribution were completed.

## 9. MCA Base Case Scenario – practical application

The process of evaluation of development options and its results with weights and preferences provide the MCA Base Case Scenario. The MBA Base Case Scenario assessment was carried out according to the methodology assumptions provided in the preceding subsections. This involves several major steps completed based on the assumptions for MBA Base Case Scenario: Assigning values to particular indicators; Normalization of values for indicators; Applying weights to indicators by the Consultant; Computation of scores by criteria; Applying preferences; Calculation of final scores. The following are the highlights of these procedures.

Table 2. Weight system for MCA indicators.

| Indicator | Assigned Indicator Weight |
|---|---|
| Economic indicators | |
| EIRR | 100% |
| Regional indicators | |
| Regional economic development impact | 40% |
| Compliance with regional development strategies | 20% |
| Social accessibility impact | 40% |
| Technical indicators | |
| Transport system capacity | 40% |
| Investment preparation risk | 40% |
| Engineering and geotechnical risk | 20% |
| Environmental indicators | |
| Impacts on natural ecosystems | 25% |
| Impacts on protected areas | 50% |
| Impacts on man-made environment | 25% |
| Legal indicators | |
| Compliance with the Schengen Acquis | 20% |
| Necessity of additional international agreements | 40% |
| International transport accessibility impact | 20% |
| Compliance with the UN Convention on the Law of the Sea | 20% |

**Economic sustainability indicators**. *EIRR (Economic Internal Rate of Return)* indicator was used to reflect economic sustainability of the development options. It was calculated according to the standard EIRR calculation procedures using the following variables: Costs: investment, maintenance and operating costs; benefits: monetarized travel time savings resulting for a given development option; EIRR was calculated for all the development options.

**Regional development impact indicators**. Three indicators were defined to reflect regional development impact of the evaluated development options. *Social accessibility impact indicator* reflects impact of development options on local communities' accessibility to the main regional and national centers. It is assessed quantitatively and measured by the number of inhabitants affected by accessibility improvements resulting for development options, multiplied by the average non-season time savings per passenger in the period 2017-2046. It concerns the area included to the traffic model prepared in this project. The impact of the development options on local communities' accessibility to the main regional centers was calculated using the following data: Accessibility impact of the project options, based on the traffic model results; Statistics on number of inhabitants in cities and municipalities, affected by accessibility improvements; Average non-season travel time savings resulting from the given development option per passenger in the period 2017-2046, based on the traffic model results. The non-season data were used because this impact concerns locals. *Regional economic development* indicator reflects changes in local and regional economies caused by development option implementation. The assessment considered key economic development factors, especially

additional tourism-related revenue for the affected area. The indicator was assessed quantitatively and measured by the gross value added for tourism related activities in Dubrovnik-Neretva county (wholesale and retail trade, transportation, storage, accommodation and food service) multiplied by the share of tourists travelling in the region, and multiplied by the % increase of leisure time (share of summer season travel time savings for average passenger in 12h). Changes in local and regional economies caused by possible implementation of development options were assessed based on the additional tourism-related revenue for the area affected. The following data were used: Gross value added for tourism related activities in Dubrovnik-Neretva county amounting to 354 mln EUR/year, Share of tourists travelling in the region: 50%; Average increase of leisure time in percent (the share of summer season travel time savings for average passenger in 12h), based on the traffic model results. *Compliance with Regional Development Strategies* – this indicator reflects the development option compliance with the strategic and planning documents on the international, national, regional and local level. This concerns strategic and planning documents such as: public investment plans/programs, development strategies/plans, transport strategies/plans, etc from EU, Croatia, and Bosnia and Herzegovina. This indicator was valued qualitatively based on data collected during the PFS by assigning points according to the following rules: 0 was assigned when the development option was not included in any international, national, regional nor local strategic and planning documents; 1 was assigned when the development option was included in international strategic and planning documents; 2 was assigned when the development option was included in national strategic and planning documents; 3 was assigned when the development option was included in national and regional strategic and planning documents; 4 was assigned when the development option was included in national, regional and local strategic and planning documents. **Environmental sustainability indicators** were calculated based on three sub-indicators: *Impact on natural ecosystems* which reflects impact of development options on terrestrial and marine ecosystems, for the most significant ecologically habitats: flora and fauna species. This indicator was assessed qualitatively. The values of the indicator were presented as cumulative values for the grouped criteria presented in the environmental report; *Impact on protected areas* – his indicator reflects impact of development options on nationally protected areas and Natura 2000 areas in the targeted area. The indicator was assessed qualitatively, based on the conclusions of the environmental assessment. *Impact on man-made environment* reflected impact of development options on land uses, acoustic and atmospheric environment and historic and cultural environment. The values for this indicator were assessed qualitatively. The value for environmental indicator is an average of value of the presented grouped criteria. **Technical indicators**. Three indicators were established to reflect impact of the evaluated development options. *Transport system capacity* – reflects the changes in transport system capacity resulting from implementation of a given development option. The assessment was focused on the capacity of roads providing connection between Ploce and Dubrovnik. It represents a reduction of existing bottlenecks between these O-D points. The indicator was assessed quantitatively and measured for each option by a bottleneck severity indicator. The transport capacity indicator was calculated according to the following formula – Transport system capacity indicator value = minimum (bottleneck) capacity of the road system in 2046/total traffic flows (relation Komarna – Zaton Doli) in 2046: 20114 vehicles/day; *Investment preparation risk* – this indicator reflects the current status of preparation of development options and estimated risk related to timely completion of the remaining activities needed for starting the construction phase. The current progress of the project options preparation and the estimation of the risk associated with the remaining preparatory steps were assessed quantitatively based on the availability of feasibility studies and technical designs and the development of the administrative procedures, the congruence with the spatial planning documentation and the necessity of international approval of construction permits or related international agreements, etc. This was represented by a risk factor which reflects possibilities of delays, cost increase risks, and chances for significant changes in project assumptions and scope. The indicator was expressed quantitatively. It was measured by the estimated number of months necessary to start the implementation phase of each project option, multiplied by the risk factor *R*. It was calculated according to the following formula: *Investment preparation risk* indicator value = total number of months needed to obtain necessary documentation to start investment implementation phase multiplied by R, where: R = 1 if there is a congruence with spatial plans and there is no requirement for international approvals of construction permits, R = 1.5 if there is no congruence with spatial plans but there is no requirements for international approvals of construction permits, R = 2 if there is no congruence with spatial plans and there is a requirement for international approvals of construction permits. The total lengths of preparation periods of development options were multiplied by the risk factor, reflecting the possibilities of delays, cost increase and significant changes in project assumptions and scope. This provides final assessment of development options for this indicator. *Engineering and geotechnical risk.* This indicator reflects the risk of experiencing engineering and geotechnical problems (complications) during the project design and construction phases of the investment. That may result from such factors as: geological, hydrological and seismic characteristics of the area where the investment is located. The estimate of this risk is related to the length of the structures (tunnels, bridges) to be constructed, weighted by the availability of

the results of geological and hydrological studies, investigations and expert opinions. The indicator was expressed quantitatively. It was measured by the estimated length of the structures multiplied by the risk factor A, which has been projected in relation to the availability of geological, hydrological investigations and other expertise. The following formula was used for these calculations: *Engineering and geotechnical risk indicator value = total length of the structures per option multiplied by A, where: A = 1 if necessary* geological and hydrological investigations, and analyses results are fully available for a given construction area, *A = 2, if necessary* geological and hydrological investigations, and analyses results are partially available a given construction area, *A = 3, if necessary* geological and hydrological investigations, and analyses results are not available for the construction area. **Geopolitical and Legal Impact Indicators**. Four indicators were used. *Compliance with the Schengen Acquis and EU legal framework* (EU external border security risk) addresses a variety of issues related to security risks for EU external borders. It takes into account such factors as: requirements of border and customs control, and security risks for the EU external border (illegal migrations & cross border crime risk). Three values have been assigned to this indicator based on expert evaluation: 1 = low risk, 2 = medium risk, 3 = high risk. *International accessibility impact.* This indicator represents impact of development options on international transfer of goods and people. The indicator was assessed qualitatively, by assigning points by experts, in three groups of impact: Impact on naval accessibility of the Port of Neum: 3 = significant restriction of naval approach to Port of Neum; 2 = minor restriction of naval approach to Port of Neum; 1 = no restriction of naval approach to Port of Neum; Impact on regional cohesion of B&H territory: 3 = significant restriction of internal accessibility of B&H territory (inside a densely populated area of B&H territory); 2 = minor restriction of internal accessibility of B&H territory (outside of densely populated areas of B&H territory); 1 = no restriction of internal accessibility of B&H territory; Impact on passengers and freight accessibility of Dubrovnik – Neretva County: 3 = significant restriction of accessibility; 2 = minor restriction of accessibility; 1 = no restriction of accessibility; Necessity of additional international agreements. This indicator reflects the need for concluding additional international agreements to implement a given development option. Development options which implementation requires advance conclusion of international agreements, legal preparations, and require political good will, are usually more difficult to implement and the process of their preparation is more lengthy than for other development options. The indicator was assessed qualitatively where: 1 = additional international agreements not needed, 2 = additional international agreements recommended but not compulsory; 3 = additional international agreements compulsory. *Compliance with the UN Convention on the Law of the Sea*. This indicator takes into consideration a possibility of a conflict between development options and the provisions of the UN Convention of the Law of the Sea, which may lead to an international legal dispute or law suit. The indicator was established qualitatively by assigning points, by an expert panel where: 1 = low risk of a potential international legal dispute or a law suit, 2 = medium risk of a potential international legal dispute or a law suit, 3 = high risk of a potential international legal dispute or a legal problems.

## 10. MCA Base Case Scenario results

The indicators described in the previous subsections were used as input values in the MCA analysis model. A number of tables were prepared to show for each scenario: a) Input Values for Indicators, b) The results of input values recalculation. Input values were recalculated into the scale from 0 to 100 and multiplied by the weight of the indicator. The result is the matrix of points assigned to the indicators by options. Prior to assigning the preferences, the points were summed up and a matrix of total number of points per criteria and option was created. The result of this step is a basis for preferences assignment. Finally preferences were assigned and the MCA Base Case Scenario results were calculated. The following are major conclusions from this application of MCA: a) Based on the established and agreed upon criteria two Peljesac Bridge options are the most competitive (Their scores are significantly higher than scores for other options), b) Immersed tunnel is the next preferable option, c) Third runner up is the extraterritorial Neum By-pass, d) Other options scored lower.

In addition to the MCA Base Case scenario described in the preceding paragraphs, three sensitivity tests for different sets of preferences have been completed. They confirmed the competitiveness of the Peljesac bridge scenarios. In sum, this MCA application confirmed effectiveness of using this methodology for assessing multidimensional and multidisciplinary transport projects. This MCA application provided fair and justified results for investment assessment. The combination of standard methods for project evaluation (CBA), with sound traffic analyses and modelling, and typical MCA procedures showed that the choice of the most advantageous option was clear. It was not the cheapest option. It was however the most economically effective and permanent solution to the problem of physical separation of two parts of Croatia. This application confirms that the value of MCA depends on imagination of experts in providing justified evaluation criteria, considering combination of standard methodologies

with MCA evaluation and finally strict adherence to the rules and logic of the MCA evaluation process (see: References). This case confirms that MCA in hands of experts is a justified methodology, but in the hands of politicians it sometimes may be challenged and contested. The decision of EU on providing funding for the selected bridge will indicate who prevailed this time.

Table 3. Final Base Case Scenario assessment results (after applying preferences).

| CRITERIA | Preferences | A1 | A2 | B | C | D | E1 | E2 | F1 | F2 | G | H |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Economic impact | 25% | 25 | 24 | 16 | 0 | 2 | 13 | 19 | 16 | 15 | 6 | 5 |
| Regional development indicators | 10% | 10 | 7 | 7 | 6 | 2 | 3 | 3 | 8 | 5 | 5 | 1 |
| Technical indicators | 25% | 25 | 21 | 20 | 20 | 16 | 16 | 16 | 23 | 19 | 17 | 0 |
| Environmental indicators | 15% | 13 | 10 | 10 | 8 | 0 | 4 | 3 | 11 | 15 | 12 | 14 |
| Geopolitical and legal impact | 25% | 25 | 25 | 10 | 9 | 22 | 13 | 13 | 13 | 13 | 16 | 9 |
| TOTAL | 100% | 98.2 | 87.8 | 63.0 | 43.3 | 42.4 | 48.8 | 53.6 | 69.8 | 67.0 | 55.7 | 29.8 |

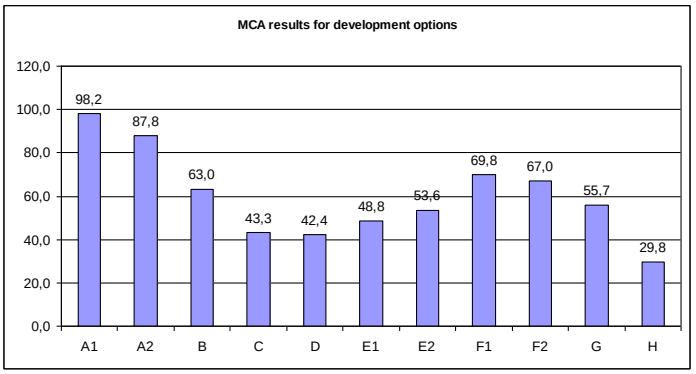


Fig 1. MCA results for transport development options for connection two separated parts of Croatia.

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